

Modeling of Laser Damage Initiated by Surface Contamination

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We are engaged in a comprehensive effort to understand and model the initiation and growth of laser damage initiated by surface contaminants. This includes, for example, the initial absorption by the contaminant, heating and plasma generation, pressure and thermal loading of the transparent substrate, and subsequent shockwave propagation, "splashing" of molten material and possible spallation, optical propagation and scattering, and treatment of material fracture. The integration use of large radiation hydrodynamics codes, optical propagation codes and material strength codes enables a comprehensive view of the damage process

The following picture of surface contaminant initiated laser damage is emerging from our simulations.

On the entrance optical surface, small particles can ablate nearly completely. In this case, only relatively weak shockwaves are launched into the substrate, but some particulate material may be left on the surface to act as a diffraction mask and cause further absorption. Diffraction by wavelength scale scattering centers can lead to significant intensity modulation. Larger particles will not be completely vaporized. The shockwave generated in this case is larger and can lead to spallation of contaminant material which then may be deposited in the substrate.

Contaminants on the exit optical surface behave differently. They may heat and pop off completely in which case no significant damage occurs. For contaminants or other surface defects that do not leave rapidly, it is possible to ignite a laser supported detonation wave, ie a supersonic absorption wave in the substrate material. Such a wave resulting from a nanosecond pulse damages a few micrometers of laser glass and serves as an absorption site for future pulses.

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